RESEARCH HIGHLIGHTS

Technical Series 99-122

# FIRE RESISTANCE TESTS ON SMALL-SCALE FLOOR ASSEMBLIES

## Introduction

In recent years, there have been a number of efforts made in North America to improve acoustic isolation in residential building environments. As a result, Canadian building codes have adopted more stringent acoustic requirements. This has led to the need for changes in traditional construction practices. At the same time, new construction materials have been developed, and many product specifications have changed that may alter the fire resistance of floor assemblies. With these changes, there has been a need to reassess existing fire resistance data for common floor constructions.

The research program set out to measure the acoustic performance of full-scale floor assemblies and the fire preformance of small- and full-scale floor assemblies. This was done to reaffirm fire resistance ratings and develop cost-effective floor assemblies on the test results.

This report describes the results of 29 small-scale fire resistance tests conducted at the Institute for Research in Construction (IRC).

Building on a preceding collaboration with CMHC, IRC at NRC developed the research plan and organized a supporting consortium. The consortium members were: Canada Mortgage and Housing Corporation, Forintek Canada, Gypsum Manufacturers of Canada, National Research Council Canada, New Home Warranty programs of Ontario, Alberta, British Columbia and the Yukon, Ontario Ministry of Municipal Affairs and Housing, Owens Corning Fiberglas Canada Inc., Roxul Inc., and the Canadian Home Builders' Association. These partners both supported the project financially, and sent representatives to meet periodically as a Steering Committee, to select specimens for subsequent study, and to adapt the findings for industry use. Several partners, most notably Forintek, also provided substantial in-kind contributions in the form of materials and material characterization. The measurements and analysis were performed by NRC.

## Assemblies and Equipment

It was determined that the parameters needed for a full-scale fire resistance test program were:

- subfloor type (oriented strand board (OSB) and plywood),
- insulation thickness (90 mm (3.54 in.), 180 mm (7.08 in.) and full cavity), and
- insulation type (glass, rock and cellulose fibre).

Twenty-nine small-scale test assemblies were constructed—eight with solid wood joists, seven

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with wood-I-joists, seven with wood trusses and seven with C-steel joists. All small-scale assemblies were constructed with or without insulation in the floor cavity and were tested unloaded.

Materials used in the assemblies included:

- Ceiling finish (Type X gypsum board).
- Framing—solid woodjoist, wood I-joist, wood truss and C-steel joist.
- Insulation—glass fibre batts; rock fibre batts; cellulose fibre insulation sprayed wet; and cellulose fibre insulation dry blown full cavity.
- Subfloor—Canadian softwood plywood (CSP) and OSB tongue and groove.
- Resilient channels of galvanized steel.

In all fabrications, gypsum board was attached to resilient channels mounted perpendicular to the joists.

Type K chromel-alumel thermocouples were used for measuring temperatures at a number of locations throughout the assembly and on the unexposed surface. Fire resistance tests were carried out using a propane-fired small-scale furnace.

## Test Conditions and Procedures

The test assemblies were exposed to heat in such a way that the average temperature of the furnace followed the CAN/ULC-S 101-M89 standard time-temperature curve as closely as possible.

The temperatures of the furnace and assemblies were recorded at one minute intervals. Average temperatures for the various assemblies with a single layer of gypsum board were measured at the following locations:

- Surface between the gypsum board and joists or trusses.
- Gypsum board surface facing the cavity.
- Joist or truss mid-height.
- Subfloor surface facing the cavity.
- Surface between the subfloor and joist or truss.

An assembly was considered to have failed if one of the following failure criteria occurred:

1. A single point temperature reading measured by one of the five thermocouples under the insulation rose 180°C above the ambient temperature.
2. The average temperature measured by the five thermocouples under insulating pads on the unexposed surface rose 140°C above the ambient temperature.
3. There was passage of flames or gases hot enough to ignite cotton waste at the unexposed surface.

## Research Results

The results of the 29 small-scale floor tests are summarized in the following page.

Based on these results, the following conclusions* can be drawn:

- The effect of the subfloor type (OSB and plywood) on the fire resistance of all small-scale assemblies is insignificant.
- For small-scale assemblies with either solid wood or C-steel joists, the effect of glass fibre insulation is insignificant. However, the effect of insulation thickness is significant for assemblies with wood I-joists or wood trusses.
- The installation of either rock or cellulose fibre insulation (90 mm thick) in the floor cavity increases the fire resistance compared to a non-insulated assembly.
- Glass fibre insulation (90 mm thick) in the floor cavity increases the fire resistance for small-scale assemblies with either solid wood joists, wood I-joists or C-steel joists compared to a non-insulated assembly. However, glass fibre insulation reduces the fire resistance in an assembly with

## Table 1. Small Scale Floor Assembly Parameters and Fire Resistance Test Results

| Assembly | Joist | | | Ceiling Finish | | | Subfloor | | Cavity Insulation | | | Resilient Channels | | Point | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | Type | Depth | Spacing | Type | Thick | Layers | Type | Thick | Type | Thick | Location | Orient. | Spacing | Failure* | Failure* |
| | | (mm) | (mm) | | (mm) | | | (mm) | | (mm) | | | (mm) | (min) | (min) |
| SF-01 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | *** | *** | *** | Per | 400 | 60 | ***56*** |
| SF-02 | WJ | 235 | 400 | X | 15.9 | 1 | PLY | 15.9 | *** | *** | *** | Per | 400 | ***54*** | 55 |
| SF-03 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 90 | B | Per | 400 | ***65*** | 66 |
| SF-04 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 180 | B | Per | 400 | ***66*** | 71 |
| SF-05 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 270 | full | Per | 400 | ***63*** | *** |
| SF-06 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | CI | 125 | T | Per | 400 | ***80*** | 81 |
| SF-07 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | RI | 90 | B | Per | 400 | 76 | ***74*** |
| SF-08 | WJ | 235 | 400 | X | 15.9 | 1 | OSB | 15.9 | CI* | 180 | B | Per | 400 | ***87*** | *** |
| SF-09 | WIJ | 240 | 400 | X | 15.9 | 1 | OSB | 15.9 | *** | *** | *** | Per | 400 | 42 | ***41*** |
| SF-10 | WIJ | 240 | 400 | X | 15.9 | 1 | PLY | 15.9 | *** | *** | *** | Per | 400 | ***42*** | 43 |
| SF-11 | WIJ | 240 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 90 | B | Per | 400 | ***51*** | *** |
| SF-12 | WIJ | 240 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 180 | B | Per | 400 | ***51*** | *** |
| SF-13 | WIJ | 240 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 270 | full | Per | 400 | ***61*** | *** |
| SF-14 | WIJ | 240 | 400 | X | 15.9 | 1 | OSB | 15.9 | CI | 122 | T | Per | 400 | ***87*** | 87 |
| SF-15 | WIJ | 240 | 400 | X | 15.9 | 1 | OSB | 15.9 | RI | 90 | B | Per | 400 | 81 | ***78*** |
| SF-16 | WT | 305 | 400 | X | 15.9 | 1 | OSB | 15.9 | *** | *** | *** | Per | 400 | ***47*** | 47 |
| SF-17 | WT | 305 | 400 | X | 15.9 | 1 | PLY | 15.9 | *** | *** | *** | Per | 400 | ***46*** | *** |
| SF-18 | WT | 305 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 90 | B | Per | 400 | ***38*** | 40 |
| SF-19 | WT | 305 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 180 | B | Per | 400 | ***47*** | *** |
| SF-20 | WT | 305 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 270 | full | Per | 400 | ***50*** | *** |
| SF-21 | WT | 305 | 400 | X | 15.9 | 1 | OSB | 15.9 | CI | 120 | T | Per | 400 | ***72*** | *** |
| SF-22 | WT | 305 | 400 | X | 15.9 | 1 | OSB | 15.9 | RI | 90 | B | Per | 400 | 82 | ***80*** |
| SF-23 | SJ | 203 | 400 | X | 15.9 | 1 | OSB | 15.9 | *** | *** | *** | Per | 400 | ***47*** | 49 |
| SF-24 | SJ | 203 | 400 | X | 15.9 | 1 | PLY | 15.9 | *** | *** | *** | Per | 400 | ***47*** | 47 |
| SF-25 | SJ | 203 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 90 | B | Per | 400 | ***49*** | *** |
| SF-26 | SJ | 203 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 180 | B | Per | 400 | ***42*** | ***42*** |
| SF-27 | SJ | 203 | 400 | X | 15.9 | 1 | OSB | 15.9 | GI | 270 | full | Per | 400 | ***47*** | *** |
| SF-28 | SJ | 203 | 400 | X | 15.9 | 1 | OSB | 15.9 | CI | 90 | T | Per | 400 | ***61*** | *** |
| SF-29 | SJ | 203 | 400 | X | 15.9 | 1 | OSB | 15.9 | RI | 90 | B | Per | 400 | 64 | ***64*** |

WJ - Solid wood joist
WIJ – Wood I-joist
WT - Wood truss
SJ - Steel joists (16 ga/18 ga)
X - Type X
CI - Cellulosic fibre insulation (wet sprayed)
CI* - Cellulosic fibre insulation (dry)
GI - Glass fibre insulation batts
RI - Rock fibre insulation batts
B - Bottom of floor cavity
T - Top of floor cavity
Ply - Plywood
OSB - Oriented strandboard
Per - Perpendicular to joists
*** - Null value

* Fire resistance is in ***bold italic*** number

wood trusses when compared to a non-insulated assembly.

- For small-scale assemblies with solid wood joists, the assembly with full cavity dry blown cellulose fibre insulation provides more fire resistance than an assembly with full cavity glass fibre insulation.

* These conclusions should not be applied to full-scale floor assemblies.

**Project Manager:** Jacques Rousseau

**Research Reports:** *Fire Resistance Tests On Small-Scale Floor Assemblies*

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A full report on this project is available from the Canadian Housing Information Centre at the address below.

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